The Portable Magnetic Loop...

An Antenna for the Lower Power Enthusiast on the Go

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Welcome to the June QRP column and *CQ's* Take it to the Field Special. This month we cover the construction of a popular and easy-to-build antenna that should be in every QRPer's arsenal … the portable magnetic loop. This antenna is ideal for hams "on the go" as it can be quickly deployed, is simple to use, and is an effective radiator, especially on the upper HF bands. Due to its compact size and low profile, this antenna also is a good choice for apartment and condo dwellers, hams who are antenna-restricted by homeowner's associations, and for HF communications during natural disasters and emergencies. I have used this antenna on the trail, at campgrounds, and at roadside parks … all with good results. Its low parts count and ease of construction make the magnetic loop an ideal project for hams of all skill levels.

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A Little Ditty on the Magnetic Loop

Do not let the loop's small size fool you. Loops measuring a few feet in diameter can provide amazing results on the upper HF bands (10-20 meters) and can be used on 30 and 40 meters as well, but with less efficiency. The magnetic loop consists of an outer loop and a smaller inner loop (generally 1/5 the size of the outer loop). Coaxial cable from the transceiver is fed to the inner loop and an air variable capacitor is connected to the larger outer loop for tuning the antenna. The loops are inductively coupled with the inner loop feeding the outer loop, like energy flowing from one coil to another in an electrical transformer. I will not venture into loop antenna theory since *CQ* Antenna Editor WA5VJB (Kent Britain) has previously touched on this topic.

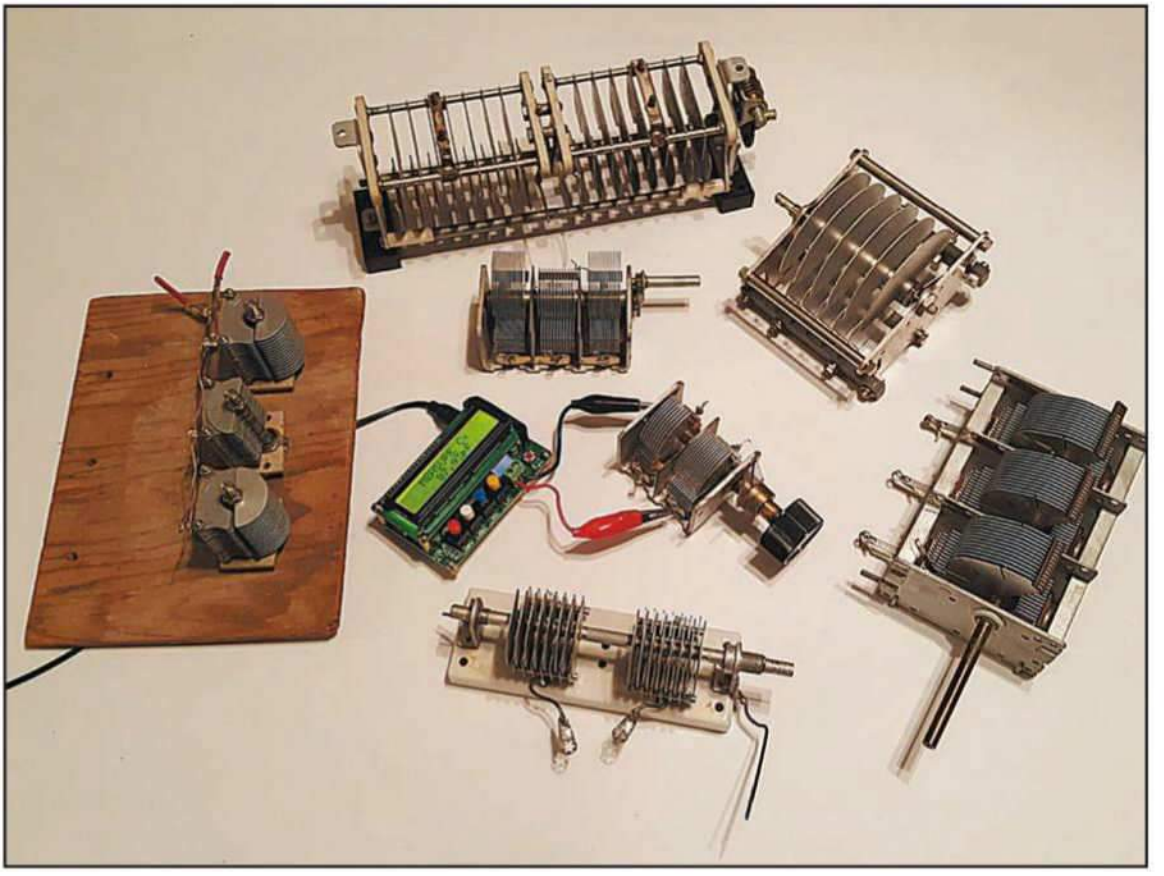

Photo A. Air-variable capacitors galore.

Photo B. Materials for the loop — not a lot to gather!

The *ARRL Antenna Book* also covers this subject in detail.

As with any antenna, there are important considerations to bear in mind, and the magnetic loop is no exception. Bandwidth is the first of two important considerations. The magnetic loop has a very narrow bandwidth, meaning the loop will need to be adjusted (via its air variable capacitor) whenever the frequency is changed more than a few kilohertz to maintain resonance. Periodically tuning the loop is generally not a problem if you are operating near the antenna (i.e. portable operation). However, if you plan to operate indoors with the loop outdoors, tuning can be frustrating since multiple trips indoors / outdoors may be needed to achieve an acceptable SWR. Ingenious hams have worked around this problem by using gear driven motors and switching assemblies to remotely tune their loops … if there's a will, there's a way.

A second consideration is power output. Magnetic loops are typically constructed as low power antennas (*but this is the QRP column, so that's good, HI – ed*). When transmitting, several hundred volts are present across the variable capacitor and outer loop, even at QRP levels, so one needs to be mindful of where the antenna is located and where others are situated while operating. For hams who prefer a little more power than QRP (*I call these hams cheaters…hi hi!*), the loop can be constructed with an air-variable capacitor that has a wider air gap between the plates to prevent arcing, or constructed with a vacuum-variable capacitor in lieu of an air-variable capacitor. It is important to keep in mind that more power means more voltage across the loop … if you accidentally touch the loop while transmitting, you may get a zinger of an RF burn.

Securing the Parts

The heart of the magnetic loop is the air variable capacitor. If you stay in the QRP realm (5 watts or less) or even push upwards to 15-20 watts, a variable capacitor from a vintage broadcast band radio will work. These capacitors can be salvaged from older tube radios and are generally available at hamfests. Recently, I purchased several variable capacitors at my local hamfest for $1 each … I have never been to a hamfest where I did not see a variable capacitor for sale. MFJ Enterprises also offers a selection of air variable capacitors for the homebrewer <www.mfjenterprises.com/catalog.php>.

Variable capacitors come in a variety of sizes and capacitance ranges (*Photo A*). A variable capacitor salvaged from a vintage broadcast radio typically has a capacitance range from about 15 picofarads (pF) to 350 pF, which is sufficient for the magnetic loop. Variable capacitors with a smaller range of capacitance can also be used; however, the loop may only be usable on the higher HF bands. Wiring two variable capacitors in parallel will provide more capacitance, allowing a broader range of frequencies to be used. Although it is helpful to know the capacitance range of the variable capacitor, it is not a necessity. I have built loops using the "plug and play" method by inserting different variable capacitors until I found one that covered the range of frequencies I wanted to operate. A capacitance meter such as the LC-100 A Meter (as seen in *Photo A*) provides an inexpensive and accurate way to determine capacitance. I purchased this meter from Amazon for less than $20 and it works great. KOØZ's "Learning Curve" column in the May 2017 edition of *CQ* covers capacitance measurements and contains additional information on the LC-100 A.

Photo B shows the items I used to construct the magnetic loop. The loop's frame was constructed using two 5-foot pieces of 0.5-inch diameter schedule 40 PVC pipe, three 0.5-inch diameter PVC T-connectors, two 0.5-inch diameter PVC 4-way connectors and one 0.75-inch diameter 4-way PVC connector.

The heavier 0.75-inch diameter 4-way connector was used on the bottom of the frame for mounting it to a tripod or stake. A reducer (0.75-inch to 0.5-inch) was used in one of the larger 4-way connector sleeves for accepting the 0.5-inch diameter PVC cross arm.

Other items include 10 feet of 0.5-inch diameter copper tubing (outer loop), two feet of 12-gauge insulated solid wire (inner loop), coaxial cable (RG-58), electrical tape, zip ties, a plastic food storage container, and an air variable capacitor. Although I already had several of these items in my junk box, I estimate the cost for this project to be around $30 if all items were purchased.

It is important to note that the magnetic loop can be constructed from a variety of different materials. My advice is to experiment and build what works for you. In the past, I have used pieces of metal coat hangers soldered together, RG-213U coaxial cable (outer braid shorted to the center conductor), and thin strips of copper fastened together as material for the outer loop. These items worked, but none provided the support necessary for use on the trail, which is why I mount the loop on a PVC frame. I used 0.5-inch diameter copper tubing for the outer loop as it is rugged and can be soldered with a 60-watt soldering iron. Larger diameter copper tubing will increase the antenna's efficiency; however, it is more expensive, weighs more (disadvantage when on the trail), and because of its size, requires a larger soldering iron or torch to ensure an electrical connection when soldering.

Loop Assembly

Below are the steps for constructing the portable magnetic loop. Refer to *Photos C* through *F* during construction for parts layout and additional detail.

Step 1: Unroll the copper tubing and form into a circle (the loop does not need to be a perfect circle). Be careful not to bend or crease the tubing as it may break in half or form a weak point. When finished, slip the three PVC T-connectors onto the pipe and place them with their connecting ends toward the center of the loop at 12 o'clock, 3 o'clock and 9 o'clock.

Step 2: Cut the PVC pipe into lengths to be used as cross-arms. Be sure to include the two 0.5-inch diameter 4-way connectors and T-connectors when measuring the length of PVC to be cut. The 4-way connector near the top of the loop is located approximately 7 inches below the T-connector in the 12 o'clock position (measured from center of the T-connector to the center of the 4-way connector). The remaining 4-way connector forms the center of the loop. Each cross bar should be approximately 36-inches long when finished. Remember to measure twice and cut once. Assemble the cross bars and use electrical tape to secure each fitting. I do not use PVC glue so I can easily disassemble the cross bars, if necessary.

Step 3: Run the coax through the side of the bottom 4-way connector (0.75-inch diameter connector) and through the center support post to the upper 4-way connector. The coax should exit the side of the 4-way connector. The 12-gauge insulated wire (two feet long) is slipped through the T-connector positioned at 12 o'clock and the 4-way connector to form the inner loop (*Photo C*). Solder the braid of the coax to one side of the inner loop and the center conductor to the other side. Seal both connections with electrical tape and slide the coax/wire connections inside the 4-way connector.

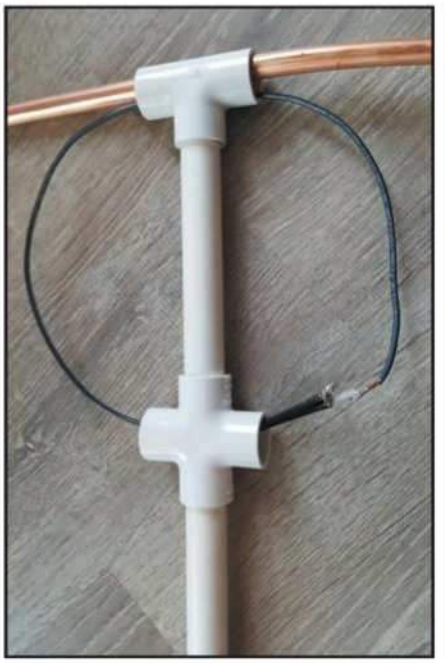

Photo C. Inner loop assembly.

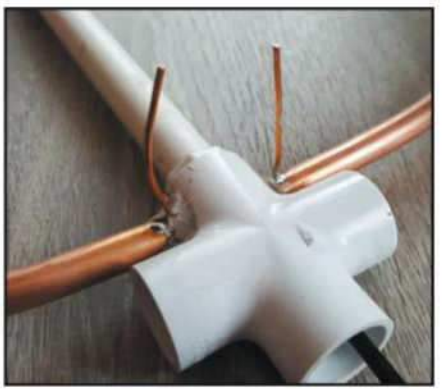

Photo D. Wiring from the outer loop to the air-variable capacitor.

It is important to note the inner loop should be 1/5 the size of the outer loop (i.e. 10-foot outer loop equates to a 2-foot inner loop). If you experiment with other loop dimensions, be sure to maintain this relationship. Also, my inner loop is not a perfect circle. I "squashed" the upper portion of the inner loop against the outer loop to help ensure a good transfer of energy. A few inches of "overlap" between the inner and outer loops is all that is necessary to achieve the necessary power transfer and a suitable SWR.

Step 4: Drill a small-diameter hole into the copper tubing on each side of the 0.75-inch diameter 4-way connector on the bottom of the loop. When finished, solder a piece of heavy gauge wire to each end of the copper tubing for connecting to the variable capacitor (*Photo D*). A 60-watt soldering iron should work fine for this task. Do not use alligator clips or hard wire the connections. It is important to solder the connections so a solid electrical connection is made. Also, keep the wires as short as possible to reduce loss.

To secure the copper tubing to the 4-way connector, I drilled a 0.5-inch diameter hole into each side of the connector and recessed each end of the copper tube inside the connector. Be careful to not let the ends of the copper tubing make contact. I used Plumber's Epoxy Putty to bond to the tubing to the connector.

Step 5: To support the variable capacitor, a piece of quarter-inch wood (i.e. panel board, Lauan board, etc.) is mounted between the 0.75-inch diameter 4-way connector and the variable capacitor. The board should be large enough to cover the 4-way connector and be of sufficient size to support the variable capacitor. Drill two holes through the board for the wires leading from the copper tubing to the variable capacitor and solder the wires to the variable capacitor. See *Photo E* for details. Use a zip tie to secure the variable capacitor to the board by drilling a hole on each side of the capacitor and slipping a zip tie through the bottom of the capacitor (be sure the zip tie does not interfere with any of the plates inside the capacitor) and each hole. Zip ties are also used to secure the board to the 4-way connector by drilling holes above and below the variable capacitor.

Step 6: Place the bottom of a food storage container over the top of the variable capacitor. The container should be

Photo E. Close-up of air-variable capacitor mounted to the board.

Photo F. Ready to go! The finished loop on its support post.

large enough to cover the variable capacitor with sufficient room for the capacitor to turn freely inside the container. Drill two holes through the top of the container and board and use zip ties to secure the plastic container to the board. Do not completely tighten the zip ties, as they are "hinges" that allow the container to be flipped upwards to provide easy access to the variable capacitor. Use scissors to cut a notch on the side of the container for the variable capacitor's shaft to pass through. The plastic cover helps keep dust and debris from collecting inside the variable capacitor and provides a degree of protection when on the trail as the capacitor's plates can be easily damaged by a passing tree branch or twig.

Step 7: Mount the loop on a support post or a heavy-duty camera tripod. The magnetic loop works well when mounted just a few feet above ground. Of course, the higher the better, but keep in mind the loop needs to be periodically tuned, so however you mount it, maintain a height that makes the variable capacitor accessible. I use a 0.75-inch diameter, 5-foot piece of PVC pipe as a mount (support post) for the loop. The support post is strapped (with Velcro) to the cross bars for ease in transporting. A rubber mallet is useful to pound the support post into the ground if you elect to mount the loop in this manner. *Photo F* shows the finished loop mounted on its support post.

Tuning the Loop

Tuning the magnetic loop is simple. Connect the coax from your loop to your transceiver (and SWR meter if your transceiver is not equipped with one), select a frequency, and turn up the receiver's volume. Slowly rotate the variable capacitor until maximum noise is heard. Tuning may be sharp, so rotate the knob slowly. Transmit and check SWR. If you do not have a suitable SWR, then tweak the variable capacitor just a bit until you have an acceptable SWR.

It is important to note that when tuning the variable capacitor for a low SWR, your hands may interfere ("hand capacitance") with the tuning procedure, making it difficult to achieve resonance. A 6-inch piece of plastic or rubber tubing inserted over the end of the shaft to extend its length should provide sufficient distance so the loop can be easily tuned without any hand interference.

Coming Full Circle

The loop (as I constructed it) covers 10, 12, 15, 17, and 20 meters with a suitable SWR. The 30- and 40-meter bands are also operable, but with less efficiency, meaning less power is being radiated from the antenna. Although efficiency suffers on the lower bands, I have made several CW and SSB contacts on 40 meters. The antenna works well on the higher HF bands with solid contacts achieved on 17 and 20 meters. When ol' sol wakes up (we had very few sunspots at the time of this writing), I'll be making contacts with the loop on 10, 12, and 15 meters, too.

This is the most travel-friendly magnetic loop I have constructed. The PVC frame allows me to hit the trail without worry of damaging the loop and I can transport it in my vehicle's trunk or back seat without issue. When on the trail, I strap the loop's PVC support to my backpack for transport or simply carry it by hand. Yes, a loop strapped to my backpack looks a bit strange and I do get some looks by passersby, but it works.

If you have not made a loop, you need to … you will be surprised at what can be achieved with such a simple antenna, especially one you built. Send me photos of your homebrew magnetic loop and I'll try and work them into a future column. Readers of this column are always interested to see what others have done!

Until August, 73.